

## **Statement of Work**

- I. TITLE:** Hedonic Housing Price Analysis of Value of Changes in Visual Air Quality  
**CONTRACTOR NAME:** Industrial Economics  
**CONTRACT#:** EP-D-14-032  
**WA#:** 3-42

**II. Work Assignment Manager (WAM):**

Jenny Thomas  
U.S. Environmental Protection Agency  
Office of Air Quality Planning and Standards  
Health and Environmental Impacts Division  
Air Economics Group, C439-02  
Research Triangle Park, NC 27711  
Phone: (919) 541-0306

**Alternate WAM**

Elizabeth Chan  
U.S. Environmental Protection Agency  
Office of Air Quality Planning and Standards  
Health and Environmental Impacts Division  
Risk and Benefits Group, C539-07  
Research Triangle Park, NC 27711  
Phone: (919) 541-3771

**III. Background:**

The evidence related to the direct preferences people express about visibility in urban and suburban residential areas is limited, largely based on a few older survey studies in a limited number of cities. In discussing the evidence related to the values (monetary or otherwise) people place on visibility, the most recently completed Regulatory Impact Analysis (RIA) for the review of the National Ambient Air Quality Standards for Particulate Matter (PM NAAQS) noted that there were only three direct preference surveys (Ely et al, 1991; Pryor, 1996; BBC Research & Consulting, 2003), all in the west, none of which provided enough information to be able to develop monetized benefits estimates because they do not provide preferences expressed in dollar values.

Studies that elicit dollar values for improvements in visibility that have occurred or are projected to occur in areas where people live and work have been limited, and thus EPA has only a limited ability to estimate the monetary value of changes in visibility that result from regulatory actions. EPA's current approach for estimating the value of visibility improvements relies on three stated preference studies conducted in the 1970's and 1980's (Brookshire et al, 1979; Loehman et al, 1985; and Tolley et al, 1986). While the current approach has been reviewed by the Science Advisory Board, there are substantial uncertainties in the estimates, and they are only applicable to a small subset of urban areas in the U.S., including Atlanta, Boston, Chicago, Denver, Los Angeles, Mobile, San Francisco, and Washington D.C. While uncertainty exists regarding the

precision and accuracy of these older, stated-preference residential valuation studies, their results support the argument that individuals have a non-zero value for residential visibility improvements.

In 2004, the Advisory Council on Clean Air Compliance Analysis (SAB-Council) recommended that the EPA evaluate the available studies addressing residential visibility and consider the possibility of using hedonic property models to estimate residential visibility co-benefits (U.S. EPA-SAB, 2004). In response to this recommendation, the EPA evaluated the existing economic literature, and determined that there were substantial limitations that precluded the Agency from using these studies to make inferences regarding individuals' willingness to pay (WTP) for improved visibility (Leggett and Neumann, 2004). Specifically, the literature did not provide support for the assumption that market participants are aware of the spatial variation in visibility, and consider this variation when purchasing a home, and can successfully separate visibility effects from health effects (Leggett and Neumann, 2004).

This current work assignment seeks to address these issues by combining visual air quality information with measures of view shed quality (elevation, land type within view shed, obstructions, etc.) to isolate the effects of reduced visibility on the available view shed around a home. Not all homes within urban areas have the same quality of view. For example, homes with views of visual amenities such as mountain ranges or water bodies have been demonstrated to have higher sales values (Sander and Polasky, 2009; Behrer, 2010; Hansen and Benson, 2013; Walls, Kousky, and Chu, 2015). The estimated hedonic model will be designed to isolate the impact of the visibility component of air quality on the value of the view sheds around single-family, residential properties. The total value of air quality will then be an average value for all people plus an additional visibility related value people place on the view sheds around their homes. The average value of visibility across all people will likely still include a portion related to health or other welfare effects, but the visibility component should be free of these confounders.

The purpose of this work assignment is to 1) provide estimates of the price (the marginal willingness to pay or MWTP) of visual air quality related to homes' view sheds, while controlling for the overall effect of air quality in the estimated hedonic models for different regions of the country, and 2) provide estimates of the non-marginal WTP for specific improvements in visual air quality by estimating the national demand for visual air quality based on the region-specific hedonic models.

This Work Assignment (WA) is an extension of work completed under WA 1-10 and WA 2-29. Under these previous WAs, the contractor compiled a housing data set with housing characteristics, price, satellite based elevation data, land types and use characteristics for the nation. The contractor also linked air quality data and housing sales data for pilot cities and provided preliminary first stage hedonic statistical results for these cities. The current WA shall expand the analysis and shall incorporate lessons learned from the preliminary analysis. The contractor shall not duplicate work performed under other current or previous contracts.

#### **IV. Description and Tasks:**

##### **Task #0: Work Plan and Monthly Progress Reports**

The contractor shall develop a work plan for this WA. The contractor shall submit the proposed work plan no later than twenty (20) days following receipt of this WA. In addition, the contractor shall provide monthly progress reports to be submitted with the invoice in the manner described in this contract.

##### **Task #1: Refine air quality and housing dataset**

Under WA 2-20 the contractor produced a dataset that included housing price data, housing characteristics, and summary measures of ambient air quality and visual air quality. Under this task the contractor shall make this dataset available to the EPA work assignment manager (WAM) as both .dta and .csv files. The dataset shall be delivered to the EPA WAM within one week of the EPA WAM requesting the dataset, unless the contractor makes the EPA WAM aware of any issues in compiling the data. The EPA WAM may also request refinements or changes to that dataset and to have those changes be documented via technical memorandum.

##### **Task #2: First stage hedonic model estimation**

The contractor shall employ the database produced under WA 2-20 and refined under Task 1 as appropriate to estimate a variety hedonic pricing models. A variety of specifications of the view and air quality variables and functional forms may be examined.

In identifying the versions of the model to run, the contractor shall work with the EPA WAM to determine (1) geographic scope, (2) air quality and visibility representations, and (3) functional forms of the pricing models to be examined. The contractor shall anticipate preparing memorandums describing the proposed model specifications, and revising that memorandum to reflect the final model specifications selected in consultation with the EPA WAM and the draft results (see below.)

The EPA WAM shall direct the contractor to run the selected model specifications via technical direction. For selected models, the contractor shall also prepare a draft pricing model technical memorandum providing draft results of the model estimation, model specification (previously prepared), methodology, and any other information necessary to fully understand and communicate the methods and results. This pricing model technical memorandum will be revised based on feedback from the EPA WAM and/or changes in results as the work progresses. The contractor shall also provide the EPA WAM with the code used to run the model in statistical software.

##### **Task #3: Second stage hedonic analysis**

The first stage hedonic price models can provide estimates of the MWTP for visual air quality given specific view related attributes. However, these MWTP are not appropriate for calculating the benefits of larger air quality improvements, because the price and quantity of the visual air

quality attribute are simultaneously selected by the home buyer. Additional information is needed to identify other points on the demand curve and therefore enable calculation of total WTP for a specific visual air quality improvement.

The hedonics literature identifies several ways that the second stage demand estimation can proceed. In general, there are two approaches to second stage demand estimation. The first approach uses hedonic price estimates estimated in separate housing markets. This approach recognizes that any variable that shifts the hedonic price function can be used as an instrument for the household choice of the quantify of visual air quality, if the variable is correlated with the choices of house attributes, but uncorrelated with unobserved tastes and preferences (Bartik, 1987). The second approach uses variation in visual air quality over time for houses with non-time varying attributes with repeat sales to recover the demand function for visual air quality. At the request of the EPA WAM, the contractor shall review this literature and prepare a technical white paper describing approaches, relevant literature, and making a recommendation as to how to proceed with the analysis.

The contractor shall discuss the technical white paper with the EPA WAM and other staff at the EPA identified by the WAM to determine the approach to be used in the analysis. At the request of the EPA WAM the contractor shall estimate second stage hedonic models to recover parameters of the demand for visual air quality. In completing this analysis, the contractor shall expect to prepare a technical memorandum describing the approach and draft results. After discussing and receiving feedback from the EPA WAM, the contractor shall prepare a final version of this memorandum. The contractor shall also provide the EPA WAM with the code used to run the model in statistical software.

## **V. QA Requirements:**

The Contractor shall identify or include references of where to find the QA criteria (e.g., data completeness minimum number of observations) that will be or that was applied to the data used in this WA. The implemented QA procedures, data sources (and data acquisition date), explanation of the appropriateness of the data for the intended use and other pertinent data qualifications shall be stipulated in all deliverables produced via this work assignment.

## **VI. Deliverables:**

<b>Task Number</b>	<b>Task</b>	<b>Deadline</b>
0	Work Plan	20 days following receipt of work assignment
	Monthly Progress Reports and Billing	Per contract requirements
1	Air Quality and Housing Dataset delivered to WAM as .dta and .csv files	Within 1 week of direction from EPA WAM
	Refinements to dataset and supporting technical memorandum, if needed	To be established via technical direction from EPA WAM
2	Memorandum of proposed model specifications	To be established via technical direction from EPA WAM

	Memorandum of final model specifications and draft results	To be established via technical direction from EPA WAM
	Code used to run model in statistical software	To be established via technical direction from EPA WAM
3	Technical white paper describing literature review and recommendations on how to proceed with 2 <sup>nd</sup> stage analysis	To be established via technical direction from EPA WAM
	Memorandum describing 2 <sup>nd</sup> stage analysis approach and draft results	To be established via technical direction from EPA WAM
	Final memorandum describing 2 <sup>nd</sup> stage analysis and results.	To be established via technical direction from EPA WAM
	Code used to run analysis in statistical software	To be established via technical direction from EPA WAM

## **VII. Reporting Requirements:**

The Contractor shall provide monthly progress reports in accordance with the terms of the contract. The Contractor shall submit work products in electronic form. In addition, the Contractor shall deliver to the WAM each draft and final report in electronic format that is readable by windows-based word-processing (Microsoft Word). The Contractor shall deliver supporting databases in .csv and .xlsx formats. Statistical code may be delivered as Stata files (.dta, .do) or in another format determined in consultation with the EPA WAM. The Contractor shall also provide electronic copies of reports in PDF format.

## References

- Abt Associates, Inc. 2001. *Assessing Public Opinions on Visibility Impairment due to Air Pollution: Summary Report*. Prepared for EPA Office of Air Quality Planning and Standards; funded under EPA Contract No. 68-D-98-001. Abt Associates Inc., Bethesda, MD. January. Available on the Internet at <[http://www.epa.gov/ttncaaa1/t1/reports/vis\\_rpt\\_final.pdf](http://www.epa.gov/ttncaaa1/t1/reports/vis_rpt_final.pdf)>.
- BBC Research & Consulting. 2003. *Phoenix Area Visibility Survey. Draft Report*. Available on the Internet at <[http://www.azdeq.gov/enviro/air/download/vis\\_021903f.pdf](http://www.azdeq.gov/enviro/air/download/vis_021903f.pdf)>.
- Behrer P. 2010. *Building in the Mountains: A hedonic analysis of the value of degraded mountain views using GIS modeling*. Harvard Environmental Economics Program Discussion Paper 10-15. May. <http://heep.hks.harvard.edu/files/heep/files/dp15-behrer.pdf>
- Beron KJ, Murdoch J, Thayer M. 2001. "The benefits of visibility improvement: New evidence from Los Angeles metropolitan area." *J Real Estate Finance Econ* 22(2-3):319-337.
- Brookshire, D.S., R.C. d'Arge, W.D. Schulze and M.A. Thayer. 1979. *Methods Development for Assessing Tradeoffs in Environmental Management, Vol. II: Experiments in Valuing Non-Market Goods: A Case Study of Alternative Benefit Measures of Air Pollution Control in the South Coast Air Basin of Southern California*. Prepared for the U.S. Environmental Protection Agency, Office of Research and Development. Available on the Internet at <[http://yosemite.epa.gov/ee/epa/erm.nsf/vwAN/EE-0271B-1.pdf/\\$file/EE-0271B-1.pdf](http://yosemite.epa.gov/ee/epa/erm.nsf/vwAN/EE-0271B-1.pdf/$file/EE-0271B-1.pdf)>.
- Ely, D.W., Leary, J.T., Stewart, T.R., Ross, D.M. 1991. "The Establishment of the Denver Visibility Standard." Presented at Air and Waste Management Association 84th Annual Meeting, June 16-21, Paper 91-48.4, 17pp. Available on the Internet at <<http://www.albany.edu/cpr/stewart/Papers/T0210-ElyDenverVisStandard-1991cap.pdf>>.
- Graves, Phil, James C. Murdoch, Mark A. Thayer, and Don Waldman. 1988. "The Robustness of Hedonic Price Estimation: Urban Air Quality." *Land Economics*, 64: 220-33.
- Hansen, JL and ED Benson. 2013. "The value of a water view: Variability over 25 years in a coastal housing market." *The Coastal Business Journal* 12(1) 76-99.
- Kiel, K.A. and M.A. Boyle. 2001. "A Survey of House Price Hedonic Studies of the Impact of Environmental Externalities" *Journal of Real Estate Literature* 9(2):117-144.
- Leggett, C.G. and J.E. Neumann. 2004. *Responding to SAB Council Comments on the May 2003 Draft Analytical Plan for the Section 812 Second Prospective—Visibility Benefits*. Prepared for U.S. Environmental Protection Agency OPA. Available on the Internet at <<http://www.epa.gov/ttn/ecas/regdata/Benefits/background/leggettandneumann2004.pdf>>.
- Loehman, E.T., D. Boldt, K. Chaikin. 1985. *Measuring the Benefits of Air Quality Improvements in the San Francisco Bay Area*. From Methods Development for Environmental Control Benefits Assessment, Volume IV. Prepared for the U.S. Environmental Protection Agency, Office of

Policy, Planning and Evaluation, September. Grant #R805059-01-0 Available on the Internet at <[http://yosemite.epa.gov/ee/epa/eerm.nsf/vwGA/e85705387833398f8525644d0053bdd0!OpenDocument#\\_Section6](http://yosemite.epa.gov/ee/epa/eerm.nsf/vwGA/e85705387833398f8525644d0053bdd0!OpenDocument#_Section6)>.

Murdoch, J. C. and M. A. Thayer. 1988. "Hedonic price estimation of variable urban air quality," *J. Environ. Econ. Management* 15, 143-146.

Pryor, S.C. 1996. "Assessing Public Perception of Visibility for Standard Setting Exercises." *Atmospheric Environment* 30, no. 15, pp. 2705-2716.

Rosen, S. 1974. "Hedonic prices and implicit markets: product differentiation in pure competition." *Journal of Political Economy* 82(1): 34-55.

Sander, HA and S Polasky. 2009. "The value of views and open space: Estimates from a hedonic pricing model for Ramsey County, Minnesota, USA." *Land Use Policy* 26(3): 837-845.

Smith, V.K., and J.C. Huang. 1995. "Can markets value air quality? A meta-analysis of hedonic property value models," *J. Polit. Econ.*, 103, pp. 209–227.

Tolley, G., A. Randall, G. Blomquist, M. Brien, R. Fabian, G. Fishelson, A. Frankel, M. Grenchik, J. Hoehn, A. Kelly, R. Krumm, E. Mensah, and T. Smith. 1984. *Establishing and Valuing the Effects of Improved Visibility in Eastern United States*. Prepared for U.S. Environmental Protection Agency, Office of Policy, Planning and Evaluation. March. U.S. Environmental Protection Agency Grant #807768-01-0. Available on the Internet at <[http://yosemite.epa.gov/ee/epa/eerm.nsf/vwAN/EE-0003-01.pdf/\\$file/EE-0003-01.pdf](http://yosemite.epa.gov/ee/epa/eerm.nsf/vwAN/EE-0003-01.pdf/$file/EE-0003-01.pdf)>.

U.S. Environmental Protection Agency—Science Advisory Board (U.S. EPA-SAB). 2004. *Review of the Draft Analytical Plan for EPA's Second Prospective Analysis—Benefits and Costs of the Clean Air Act, 1990-2020: An Advisory by the Advisory Council for Clean Air Compliance Analysis*. EPA-SAB-COUNCIL-ADV-04-004. May. Available on the Internet at <[http://yosemite.epa.gov/sab/sabproduct.nsf/7CCBBFE15.BD4C8B185256F17005E3079/\\$File/council\\_adv\\_04004.pdf](http://yosemite.epa.gov/sab/sabproduct.nsf/7CCBBFE15.BD4C8B185256F17005E3079/$File/council_adv_04004.pdf)>.

U.S. Environmental Protection Agency. 2012. *Regulatory Impact Analysis for the Final Revisions to the National Ambient Air Quality Standards for Particulate Matter*. Office of Air Quality Planning and Standards, Research Triangle Park, NC. EPA-452/R-12-005. December. <http://www.epa.gov/ttnecas1/regdata/RIAs/finalria.pdf>

Walls M, C Kousky, and Z Chu. 2015. "Is What You See What You Get? The Value of Natural Landscape Views." *Land Economics* 91(1): 1-19.